ENVIRONMENTAL QUARTERLY

Vol 3 #3

In This Issue...

Human Occupancy in the Environmental Chamber

Testing in the Ultimate Environment—*Time*

How Environmental Test Conditions Influence Reliability

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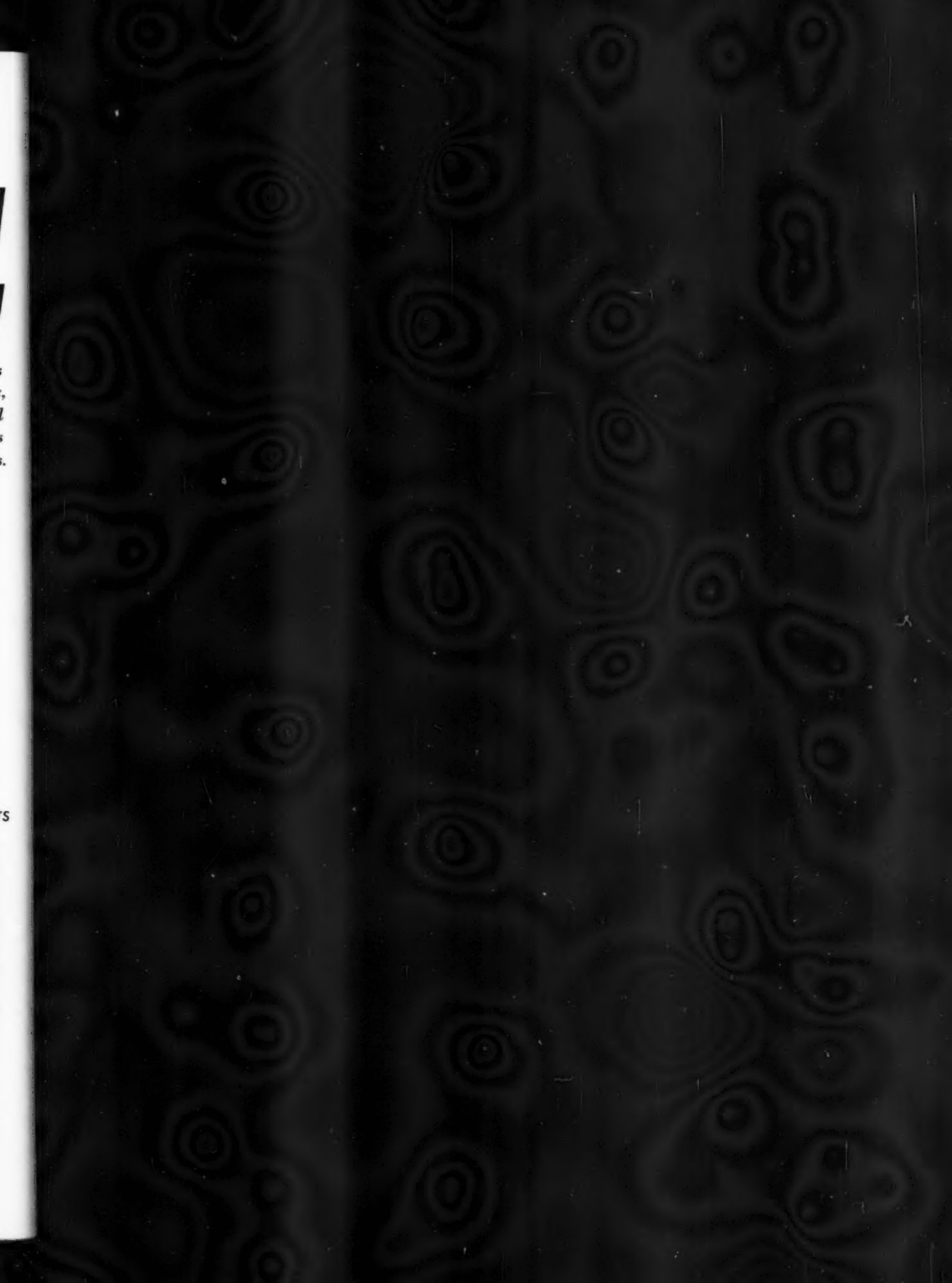

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	I plan to submit articles for use in the Environmental Quarterly.		Please send me a kit of materials for starting a local chapter in my area.
	I would like to contribute papers for presentation at the annual meeting..		I am available for speaking at local chapter and other meetings.
	I would like to help prepare material for the Handbook of the Environment.		I can provide movies, slides, and other material for use at meetings, etc.

(Please list below the subjects and topics on which you are qualified to speak and/or write.)

ADDITIONAL INFORMATION

Vol. 3, No. 3 Third Quarter 1957

ENVIRONMENTAL QUARTERLY

Official Publication of the Environmental Equipment Institute and the Institute of Environmental Engineers

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Arthur B. Billet, *Vice President, Local Chapters*

Irving P. Polak, *Vice President, Membership*

Human Occupancy in the Environmental Chamber 18
by Stuart Giles, BEMCO
Strict discipline is a must. A dash into a −65° F chamber in street clothes to make a "quick" adjustment could cost you both ears and the end of your nose.

Life Testing 4
by E. F. Peacox, Stromberg-Carlson
The ultimate test is survival in time. The author offers simple techniques for calculating survival probabilities.

How Environmental Test Conditions Influence Reliability 8
by Charles Morrow, Ramo-Wooldridge
Environmental testing is one of the cornerstones of a reliability program.

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— nearly 500 attend.

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Introducing Members of the EEI. No. 2 in a Series: 20
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The *Environmental Quarterly* is circulated to men concerned with environmental simulation and testing in industry, Government and our universities. It is the only magazine devoted exclusively to environmental science, simulation, and testing.

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MANUFACTURING MEMBERS OF THE EEI: Alpha Electric Refrigeration Co., Detroit, Mich.; American Research Corp., Farmington, Conn.; Bemco, Inc., North Hollywood, Cal.; Bowser Technical Refrigeration, Terryville, Conn.; Cincinnati Sub-Zero Products, Cincinnati, Ohio; Harris Refrigeration, Cambridge, Mass.; Hudson Bay Co., Chicago, Ill.; International Radiant Corp., Port Washington, N. Y.; Murphy & Miller, Inc., Chicago, Ill.; Standard Cabinet Co., Carlstadt, N. J.; and Tenney Engineering, Inc., Union, N. J.

ASSOCIATE MEMBERS OF THE EEI: Dean Products Inc., Brooklyn, New York; Bristol Company, Waterbury, Conn.; and Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

The General Manager Speaks . . .

The First Annual Technical Meeting of the IEE and Equipment Conference of the EEI lived up to its advance billing. Those of us who had anything to do with the administration, the officers and members of the various meeting committees, put in a busy three days. On Wednesday, April 24, when most conferees were cleaning up their desks in preparation for being away for two days, we were hard at work. On that day the Federal Trade Commission held its final hearing on the Fair Trade Practices Code for the environmental equipment industry, and the EEI held its Annual Closed Meeting for Members. In addition, the Executive Committees of the two organizations held their separate meetings, and the Joint Council met to decide upon matters of common interest.

All of this activity was only a prelude for the two days that were to follow. The Pre-Registration on Wednesday evening gave us advance warning that this was to be the biggest meeting of environmental test engineers ever held. The total number registered when the books were finally closed was four hundred and seventy-two. This compares with a little over three hundred last year, and one hundred and seventy on the first year.

The steady growth in meeting attendance justifies the confidence of the founders of EEI, who first conceived of the idea of an annual technical meeting for environmental test engineers. There is no doubt now in anyone's mind that these engineers want and need such meetings. Judging by the enthusiasm of those who attended, we have not yet reached the peak in attendance. Many of those with whom I talked had come this year because an acquaintance had told him about the programs of the preceding years. This sort of grapevine publicity has a snowballing tendency. With more people talking about our program, we can expect even more to come and see for themselves next year.

The next Annual Meeting will be held in New York City, where we shall be guests of the New York Chapter. If the local meetings these engineers have been holding is any indication, we can expect an outstanding show in April, 1958. It is not too early to start planning to attend it. More important, it is not too early to offer your help. The Meeting Committee, headed by Mr. Roger Amorosi, welcomes any suggestions for papers and speakers. You can help to make the program more worthwhile by letting him know what topics you find most interesting.

GEORGE D. WILKINSON
General Manager, IEE and EEI

— CALENDAR —

AUGUST

11-15	ASME. Heat Transfer Conf. at Penn. State Univ., Univ Park, Pa. Write soc. HQ, 29 W. 39th St., New York City
12-15	SAE. West Coast Mtg. at Olympic Hotel, Seattle. Wr soc. HQ, 485 Lexington Ave., New York City 17.
26-28	Gas Dynamics Symp. at Technological Institute of Nort western Univ. Sponsored by Am. Rocket Soc. and N Univ. Write Dr. Ali Bulent Cambel, Gas Dynamics La Northwestern Univ., Evanston, Ill.
28-30	Am. Inst. of Electrical Engrs. Pacific General Mtg. to held in Pasco, Wash. Write AIEE HQ, 33 W. 39th S New York City 18.
28-30	International Conf. on Gas Chromatography at Mic State Univ. Sponsored by ISA. Programming by Analy Instrumentation Committee. Contact Herbert S. Kindl Dir. of Technical Programs, ISA, 313 Sixth Ave., Pit burgh 22.

SEPTEMBER

9-13	12th Annual Instrument Automation Conf. & Exhibit the ISA. Public Auditorium, Cleveland.

OCTOBER

1-5	SAE Aeronautic Mtg., Aircraft Production Forum a Aircraft Engring Display, The Ambassador, Los Angel
4-9	82nd Semi-Annual Conv., by SMPTE. Sheraton Hot Philadelphia.
7-9	Nat'l Electronics Conf., sponsored by IRE, AIEE, RETM & SMPTE, Hotel Sherman, Chicago.
17-18	13th Annual Conf. on Industrial Hydraulics. Hotel She man, Chicago. Raymond D. Meade is Conf. Secretary.
23-25	Fall mtg of Nat'l Fluid Power Assn, Washington, D Write Barrett Rogers, NFPA, 1618 Orrington Av Evanston, Ill.
24-25	Computer Applications Symp., by Armour Res. Found Sherman Hotel, Chicago.
27-29	East Coast Conf. on Aeronautical & Navigational El tronics, by IRE. At Lord Baltimore Hotel & 7th Re Armory, Baltimore.
27-29	Radio Fall Mtg., by IRE. Sheraton Hotel, Rochester, N
28-31	2nd Winter Mtg., Am. Nuclear Soc., Henry Hudson Hot New York City. Contact John Burt at J. M. Mathes, In 260 Madison Av., New York City 16.
31-Nov. 1	Electron Devices Mtg., by IRE. Shoreham Hotel, Wa ington, D.C.

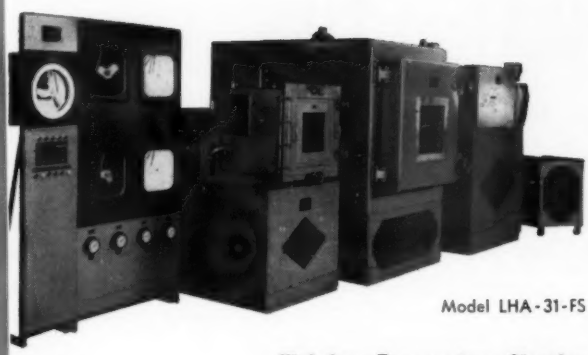
ENVIRONMENTAL PUBLISHING COMPANY FORMED BY IEE AND EEI

Under the guidance of Dr. George D. Wilkinson, Ge eral Manager of both the EEI and the IEE, a new publi ing enterprise, the Environmental Publishing Compan Inc., is in process of formation.

It will be owned jointly by the EEI and the IEE.

The publishing firm will be responsible for the publi tion of the *Environmental Quarterly*, the *Handbook the Environment*, and other publishing projects in t environmental field.

Offices of the new corporation will be at 9 Spring Stre Princeton, N. J.



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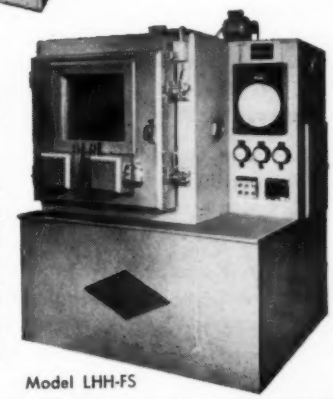

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TESTING in the ENVIRONMENT of TIME

E. F. PEACOX, Stromberg-Carlson Div., General Dynamics Corporation

This article describes the basic life-test technique, suggests two ways for shortening testing time, and shows a simple technique for estimating the probability of survival for any given period of time..

Time is the Ultimate Environment

Equipment that survives in the environment of time is considered reliable. A product that does not survive, or stand up in service, is certain to be replaced. The technique of determining the probability of survival by means of a technique called *life-testing* is gaining attention in the field of electronics and deserves consideration in other manufacturing and testing fields where durability, reliability, or long, trouble-free service is desired by the customer.

The determination of the chance of survival may be made in the engineering design process, or later in controlling quality during manufacture. It may be made under ambient conditions or under conditions of increased severity in controlled simulated environments where temperature, altitude, humidity, or vibration is the major life-determining factor.

Devising a Life Test

In devising a life test, we must present maximum opportunity for the equipment to fail. We must know the principal modes of failure, and the conditions of service in the customers' hands. A careful study of several equipments that have failed is an excellent beginning. How did they fail? Can we simulate the conditions and observe another failure? If we pursue these questions to the point of answers, we will learn what is wrong and what can be done to prevent failure. Unless we can induce failures to occur in conditions simulating end-use, we cannot begin to collect life test data or use it to estimate survival rates.

As an example, take the life-test of a television receiver. Suppose we place a television receiver in a room, turn it on, tune in a station, and observe elapsed time. Are we life-testing? Not really. We must do more. We must operate the channel selector, the fine tuning control, being sure to make it hit the stops, if any; turn the set off and on, adjust the various knobs, turn the volume up and down, ram it with a few toys, and to be realistic, spill some liquid on the polished cabinet. Even this is not enough. Some customers will have high line voltage. Some will place the receiver in a damp cellar recreation room. We must think about environment in terms of humidity, temperature, altitude, and all the other familiar conditions which help to shorten the life of electrical or electronic apparatus. We must simulate end-use, remember, and give maximum opportunity for the equipment to fail.

Further, we must have some measures of performance to monitor. Then, as time passes, we can measure performance degredation. Also, we must define failure, and arrange to evaluate all occurrences which look like failures. If we are going to analyse data, we must have data. Only failures are data. Thus, we must have failures. The more failures, the more exact our estimate of the failure rate, or mean time between failures.

In our example of the television receiver, we would find that the receiver would run a long time without failure and data would be collected very slowly. Latent weaknesses might exist, and not be uncovered for a long time. Can we speed up this testing somehow, and get our answer sooner? How can we save time?

Whether your interest lies in testing electronic apparatus, hydraulic pumps, valves, rubber tires, or door hinges, there *is* an answer: *run numerous tests of the same kind at the same time.*

It is not necessary to present the mathematics of the *Poisson* exponential binomial limit; there is an extensive literature on the subject, and we will let the statisticians explore this field. We merely want to use some of their simpler methods of analysing data.[1]

Tests in Parallel

By running tests in parallel, or simultaneously, we collect data as rapidly as we wish. Statistically it is the same as running life-tests end-to-end, up to the time of actual wearing-out of some part of the equipment. The gain in time we can realize will be determined principally by the number of equipments we can commit to this test program. If the equipments have a very long life we can collect some data from a large number without running any one very long. We should, however, run our test long enough

MR. PEACOX has been Chief of Quality Control of the Electronics Division at Stromberg-Carlson since 1945. He is a member of the American Society for Quality Control, is past president, Rochester Society for Quality Control, and is a member of the Institute of Environmental Engineers, New York Metropolitan Chapter.

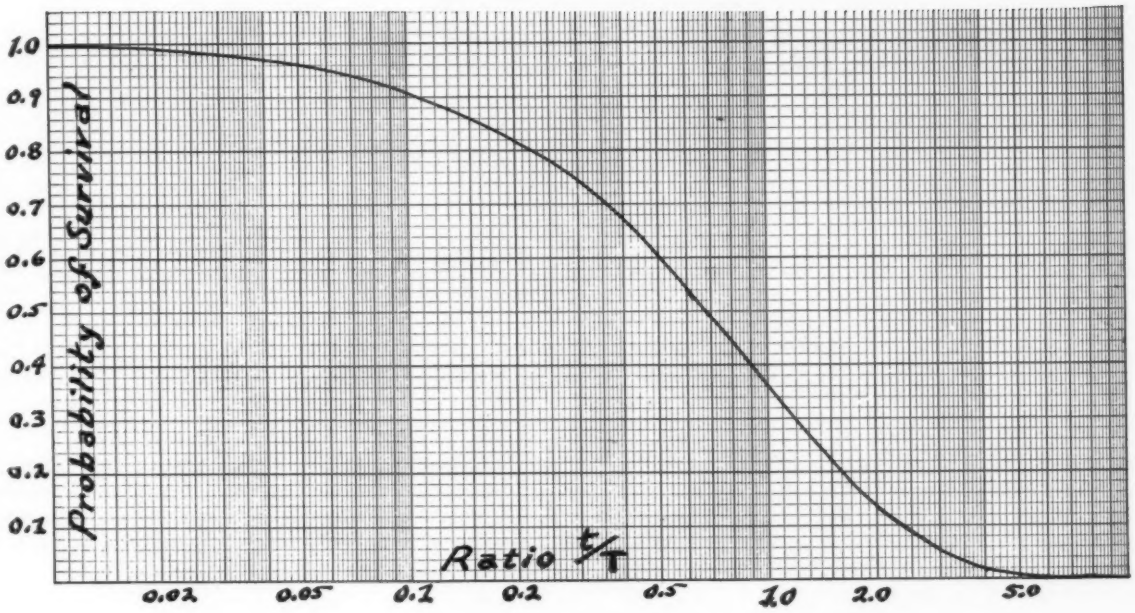

Figure 1.

to experience failures, otherwise we waste a large proportion of the time we devote to the test.

From this data we very easily calculate the average *time-between-failures.* Add up the total equipment-hours, and divide by the number of failures. You now have the number you need to determine the probability of survival. Survival simply means: continued operation without failure.

Table I shows how to determine the probability of survival in terms of the ratio of the period of time we wish the equipment to survive to the average, or mean, time-between-failures.[2] A graph of the same probability of survival versus the ratio of the period of time we wish the equipment to survive to the average, or mean, time-between-failure is shown in figure 1.

From this we see that if we desire a high probability that one equipment will survive for a given period of time, we must have a much higher value of mean time-between-failures. For example, if we run an equipment for a period of time equal to the mean time between failures, the chances are that it will survive only 36.8 percent of the time. If, however, we run the equipment for a period of time equal to one-tenth the mean time-between-failures, the probability of survival is 90.5 percent. The moral? We must somehow improve what we manufacture until it has attained a long average time-between-failures. Then the probability of survival will be a high value. Now again, the life-test tends to consume much time, as the interval between failures increases with product improvement. Can we shorten the test time?

Increasing Severity of Test

There is a way to shorten the time required to test. Again it is simple. We merely increase the *severity* of the test.[3] We must be careful not to increase severity to the point where we change the modes of failure. We merely want to accelerate the rate at which failures of the usual kind occur. Engineering judgment is required to determine how far to go in this direction. Of course, in changing the conditions of testing to save time, we change the meaning of the data. The average time-between-failures under

(Continued on Page 14)

TABLE I

Ratio t/T	Probability of Survival
3.0	5.0%
2.0	13.5%
1.5	22.3%
1.0	36.8%
0.5	60.7%
0.4	67.0%
0.3	74.1%
0.2	81.9%
0.1	90.5%
0.05	95.1%
0.02	98.0%

NOTE: t is the time for which the probability applies; T is the average time-between-failures. Probability is here expressed in percentage, although, strictly, it is a number between 0 and 1.0.

Institute of Environmental Engineers Elects Officers and Holds FIRST ANNUAL TECHNICAL MEETING

Speaker calls environmental testing essential in sound designing of nuclear reactors.

The Institute of Environmental Engineers held its first Annual Technical Meeting in Chicago on April 25 and 26 with an attendance of nearly 500. This attendance compares with slightly over 300 in 1956 and 170 in 1955 when this group was the Science Section of the Environmental Equipment Institute.

In a luncheon address on the second day of the meeting, Dr. Alan E. Surosky, Nuclear Develpoment Corporation of America, referring to submarine intermediate reactor design, said: "Those components which were accepted on faith, where it was felt that previous experience was sufficient to insure integrity, and where adequate [environmental] testing was not performed, have proved to be the nemesis of the *Sea Wolf* reactor. Dr. Surosky's address, "Propulsion Reactor's and Their Environments," was delivered by Dr. Arthur W. Flynn, also of Nuclear Development Corporation. Dr. Surosky had been hospitalized by a knee injury.

The meeting was labelled a huge success by many of th engineers who attended, and the new president of the IE Mr. Henry F. Sander, Vapor Heating Corporation, Ch cago, predicts a vastly better program than even this on for the 1958 season.

After the mail ballots had been cast in the first nation election of the IEE, the Executive Committee for the ye 1957-58 was shown to be the six men whose photograph and names are shown here.

Already plans are being made for the 1958 meeting an a committee report on that subject appears elsewhere i this issue of the Quarterly.

The committee responsible for the successful 1957 mee ing were: Chairman, Stephen S. Danko, Motorola, Inc Roger J. Amorosi, Parameters, Incorporated; Harold C Jones, Westinghouse Air Arm Div; Henry F. Sande Robert L. Stallard, The Glenn L. Martin Co.; and Geor D. Wilkinson, General Manager of the IEE.

SPEAKERS' TABLE DURING IEE ANNUAL MEETING LUNCHEON ON APRIL 25th

Left to right: **John R. Grimm, Wright Air Development. *Center:* Ray H. Mattingley, *Environmental Quarterly;* Stephen S. Danko, Motorola, Inc., and chairman of the meeting; Brig. Gen. Horace M. Wade, Strategic Air Command; Henry F. Sander, Vapor Heating Corp., and President, IEE; George D. Wilkinson, General Manager, IEE; John Cammarata, American Bosch Arma Corp., and Vice-Chairman of N. Y. Local Chapter of IEE; Roger J. Amorosi, Parameters, Inc., and Executive Vice President, IEE; G. W. Gerhardt, Wright Air Development Center; Harold C. Jones, Westinghouse Air Arm Div., and Vice President, Fiscal Affairs, IEE; Arthur Billet, Vickers, Inc., and Vice President, Local Chapters, IEE; D. G. Douglas, Rocketdyne Div. of North American Aviation; Robert L. Stallard, Martin-Denver; and P. H. Brandt, Murphy & Miller, Inc.**

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Vice President, Local Chapters

BILLET. Senior Staff Engineer, Aero Hydraulics Div. of Vickers, Incorporated. Member Society of Automotive Engineers and Engineering Society of Detroit. Studied aeronautical engineering at University of Michigan.

CAMPBELL. Senior Research Engineer, Convair Astronautics. Member Institute of Radio Engineers. BA, Mathematics, Am. Int'l College, Notre Dame, and Trinity College. MA, Mathematics, Boston Univ. Graduate study, N. Y. Univ.

SANDER. Chief Test Engineer, Vapor Heating Corporation. Member Society for Experimental Stress Analysis and Instrument Society of America. Attended Illinois Institute of Technology and Northwestern University.

AMOROSI. President, and coordinator of engineering and test projects, Parameters, Inc. Member New York State Society and National Society of Professional Engineers, BS and MS, Electrical Engineering, Cornell 1948 and 1950.

JONES. Senior Engineer, Environmntal Test Section, Air Arm Division, Westinghouse. Member American Institute of Electrical Engineers. BS, Electrical Engineering, Illinois Institute of Technology, 1949.

POLAK. Section Supervisor, MJL Operations, Marquardt Aircraft Company. Formerly project engineer, Aero Engine Lab, Naval Experimental Station. BS, Mechanical Engineering, Pennsylvania State University, 1942.

The proceedings of the meeting were being prepared for publication as this issue went to press and are expected to be ready for distribution very soon. Abstracts of most of the papers presented are shown below.

"Air Force Explosion Testing Techniques," G. W. Gerhardt, Wright Air Development Center. *Reviews need for explosion testing and presents history of test facilities and techniques. Forecasts future techniques and facility and apparatus design.*

"Qualification Testing of High Temperature Aircraft Hydraulic Pumps," A. B. Billet, Vickers, Inc.

With the advent of Jet Fighter Aircraft and its continued development for higher performance have come numerous problems in the qualification testing of hydraulic components. These new problems center largely around temperatures of 275°F to 550°F.

"Sinusoidal, Random, and Sinusoidal Plus Random Excitation," F. George, General Electric Corporation

Five phenolic wiring boards of varying areas were subjected to sinusoidal, random, and sinusoidal plus random excitation. The vibratory response was sensed by accelerometers placed identically on all boards for the different types of excitation. Actual test results are analyzed and conclusions presented.

"Environmental Testing With Random Noise Vibration," D. C. Douglas, Rocketdyne Division of North American Aviation

Laboratory tests of rocket engine components subjected to an environment of random noise vibration are discussed. A procedure whereby an engineer may determine the operational response of non-linear elements to vibration.

"High Altitude Missile Guidance Equipment Tested on the Ground," P. H. Brandt, Murphy & Miller, Inc.

Altitude 120,000 feet, temperature 110° below zero. The problems of simulation and instrumentation.

"Ram Air Simulation During Temperature Altitude Tests," Dr. Neal A. Cook, Westinghouse Air Arm Division

The difficulty of performing temperature-altitude tests on non-pressurized electronic equipment while maintaining internal cooling from an external source.

(Continued on Page 13)

How Environmental Test Conditions Influence Reliability*

CHARLES T. MORROW, The Ramo-Wooldridge Corporation

Environmental testing has become one of the cornerstones of a reliability program.

A traditional part of any weapons system development, and also of the production phase, is an environmental test program. I shall discuss primarily the development phase, but the two phases have much in common in respect to environmental considerations. The weapons system must perform properly and be reliable under environmental conditions of service use and transportation. These are different conditions from those of the assembly bench, hence there is an emphasis by the military on environmental test. This emphasis came into being before the more abstract concept of reliability had received much philosophical investigation, and it gained more force as many companies either did not recognize that service conditions are different from normal laboratory conditions, or did not accept a realistic responsibility for making their equipments reliable in service.

The technology of environmental test, and in particular of combined environments, is still in its infancy, as is most of the more general technology of reliability. By the technology of reliability, I mean those supplementary measures necessary to make a complicated weapons system and its components reliable in service to a short schedule, when it is possible to obtain only rudimentary information about the service failures and their causes.

Nevertheless, the importance of environmental test has not decreased. It has become more and more one of the cornerstones of a reliability program, because the results of an environmental test are conveniently measurable, because the test can be made a requirement on the contractor, and because it leads directly to detailed information useful in the redesign of a component.

DR. MORROW is a member of the Technical Staff at Ramo-Wooldridge, where he has made contributions in the fields of reliability and shock and vibration. Former employment was with the Hughes Aircraft Co. and the Sperry Gyroscope Co. Dr. Morrow received the S.D. degree in communication engineering and acoustics from Harvard Engineering School in 1946.

Reliability Objectives

One way to make the approach to reliability mo quantitative is to state numerical reliability objectives terms of the ratio of successful to total missions. At t system level, this is easily done, and the success of t system in attaining the prescribed reliability, if it do is at least marginally verifiable.

At component and subassembly levels, the reliabil objectives are still useful, but they encounter some pr tical difficulties. If we assume that the failures are co pletely independent, we find that the reliability of t system is equal to the product of the reliabilities of components, and likewise for further subdivisions. W this formula and some simple arbitrary rule for app tionment of reliability among components, among s assemblies, and so on, we can prescribe reliabil objectives at any level. But not many subdivisions ta place before the objectives become phenomenally cl to unity, or in other words to perfection, and if achiev are not verifiable directly in a program of permissi size. The numbers certainly make the magnitude of t reliability problem vivid and explain clearly why we ha not had more spectacular success with it.

For failures that are not entirely independent, the quirements are less severe, but it is not safe to assume th many of the failures are not independent.

Thus, as we prescribe reliability objectives at lo and lower levels of subdivision, we have a small do as to the realism of the prescriptions, and we encoun difficulty in verifying that the objectives have been m Furthermore, although the objectives are useful as an to design choices in special cases, this type of applicat is limited. We therefore find it necessary to prescr supplementary measures such as environmental test, wh correlate only partially with the reliability goals, but be used as requirements and do lead more frequently information useful in design or design changes. The st ment of the test serves indirectly as a definition of service environmental conditions, but is basically a fo

**First presented at a symposium on environmental testing sponsored by Society of Automotive Engineers at the University of California. Published the permission of the SAE.*

ible test rather than a detailed description.

Qualification and Sampling Tests

In the development phase, a component is required to pass environmental tests, frequently called qualification or design approval tests, that are intended to insure adequacy of design. In the production phase, a component is ordinarily required to pass sampling tests of a similar nature, that are intended to demonstrate that the design has not deteriorated in the course of the changes required by the production process, and that an adequate standard of workmanship is feasible. In the development phase, it should be permissible to repair and retest a failed component to determine whether the failure was inherent in the design or due to defective workmanship in the particular item tested. It is not possible to evaluate completely the feasibility of maintaining the workmanship required by the design until the production phase, partly because large numbers must be tested, and partly because the manufacturing methods change in going from development to production. In the sampling test, a failure due to workmanship should be considered almost as serious as a failure inherent in the design, and may require design as well as process changes.

Tests for Control of Quality

Shock and vibration tests are frequently prescribed as routine tests for components coming off the assembly line, prior to acceptance. The severities, and in particular the test duration, should not necessarily be the same as for design approval or for sampling. The objective is not to produce the same damage as would be produced in service before the component is used, but to stress the component briefly within some reasonable margins of its design limits so as to identify defectives without damaging or decreasing the service life of those items whose endurance is close to their design limits.

There has been some controversy over whether such tests increase or decrease reliability, but in my experience they have been beneficial. There are some simple criteria to settle this point in any specific case. For example, if repairs and replacements are made until each item passes test once, and the components then have a much greater chance of passing a retest than they did of passing their first test, reliability has been improved. Furthermore, if the failed items all showed evidence of defective workmanship, reliability has been improved. In other situations, the test may be too severe or prolonged, or the design may be inadequate.

Environmental Test Requirements

Environmental test cannot by itself insure reliability, for there are many failures that do not correlate with the standard environments. An obvious example is the failure of a hydraulic valve because of dirt in the hydraulic fluid. An extensive program must also be carried out that is capable of dealing with non-evironmental failures. However, reliability is not likely to be achieved unless environmental tests are required.

(Continued on Page 16)

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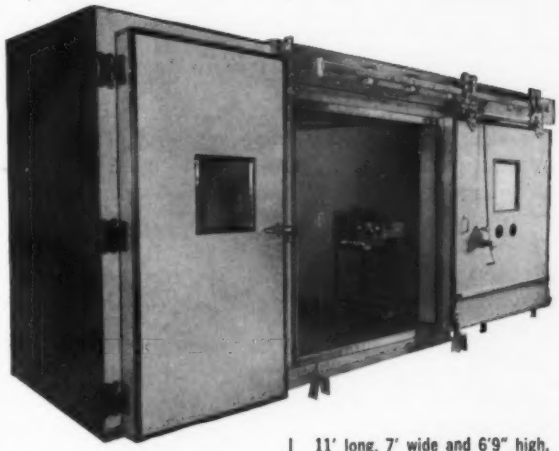

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EEI HOLDS FOURTH ANNUAL MEETING AND ELECTS OFFICERS

FTC Sponsors Hearing on Environmental Equipment Industry Rules

At its fourth Annual Meeting, the Environmental Equipment Institute elected Mr. E. S. Brown, President of Standard Company, to be President during the 1957-58 year. The meeting was held in Chicago on April 24 immediately following the Federal Trade Commission public hearing on trade practice rules for the environmental equipment industry.

Others elected to the EEI Executive Committee are: Executive Vice President, Mr. R. J. Jacobson, President, Cincinnati Sub-Zero Products; Mr. Robert H. Brown, Vice President, Tenney Engineering, Inc.; Mr. Alexander I. Newman, President, Hudson Bay Co., Div of Labline, Inc.; and Mr. Jack Shamroth, President, American Research Corporation.

Chief subjects for discussion at the meeting were the Equipment Conference to be held on the following two days in conjunction with the Institute of Environmental Engineers' Annual Technical Meeting (story on page 7), the FTC public hearing on trade practice rules, and the EEI's Seal of Approval program.

The EEI passed a resolution authorizing the establishment of an annual international award to the person contributing most to the field of environmental simulation and testing. The project was turned over to a committee for development.

FTC Sponsors Public Hearing

Under the direction of Mr. William Dixon, FTC attorney, the Commission held a public hearing for proposed fair trade practice rules for the environmental equipment industry in Chicago on April 24. The Commission had previously distributed a draft of the rules to the industry and to the public and had announced the hearing so that all concerned might voice opinions prior to the finalizing of the rules.

The establishment of a code of fair trade practice rules for the environmental equipment industry has been a project of the EEI since 1953, and on October 19, 1956, representatives of the industry met in New York City to confer with the Federal Trade Commission on a set of rules proposed by the EEI.

The Federal Trade Commission was created by Congress in 1914, along with the passage of the Clayton Act, to stop monopolistic and unfair competitive practices in their incipiency. Recognizing the probability of unfair practices not covered by the Clayton Act, the Congress charged the new Commission with the general responsibility of "preventing unfair methods of competition in commerce."

Work of the FTC takes many forms, but one of its most significant activities is the working out of fair trade practice rules with specific industries on a voluntary basis.

Fair Trade practice rules deal with all practices that are likely to take place within an industry, but are particularly concerned with the prevention of deception.

Fair Trade practice rules are worked out in two groups. Group I rules are developed from the Commission's interpretation of its laws as they relate to the practices of the industry. Group II rules represent the concensus of the industry involved as to ethical practices that are not covered by law.

Seal of Approval Program

One of the first completed projects of the EEI was the establishment of a program of equipment certification for qualified members. Under the EEI Seal of Approval Program, only those members who can satisfy the Executive Committee of the EEI that they have engineering staff and manufacturing facilities competent to produce high quality environmental test equipment are granted the privilege of using the Seal of Approval.

The stated purpose of the Seal of Approval Program is to nurture practices that will lead to the highest attainable state of the art in equipment manufacture and will at the same time develop a climate of ethical practice second to none.

When an EEI member accepts the right to use the Seal of Approval, he pledges himself to:

- Submit to each prospective customer exact engineering specifications of construction and performance prior to or at the time of accepting an order.
- Comply with all procedures established for administering the Seal of Approval Program.
- Honor all legitimate complaints on the part of the customer regarding failure of the equipment to meet specifications.
- Honor the letter and the spirit of any warranty or agreements entered upon at the time of receiving the order.
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EEI SPONSORS EQUIPMENT CONFERENCE

In conjunction with the First Annual Technical Meeting of the IEE, the Environmental Equipment Institute conducted a conference on environmental and related equipment in Chicago on April 25 and 26.

The manufacturing members of the EEI maintained booths staffed by their engineers and officers and offered continuous consultation to the engineers and scientists who were participating in the technical meeting of the IEE.

In addition to the manufacturing members of the EEI, three other companies occupied booths for the display of their equipment or literature. These were Barry Controls, NRC Equipment Corporation, and Hotham Corp.

Mr. Nick Miller or Murphy & Miller, Inc., Chicago, was in charge of arrangements for the conference. A more extensive and elaborate equipment meeting is planned for 1958. Place selected is New York City and tentative dates are April 24 and 25.

BULLETIN. – Just as this issue was going to press, the Federal Trade Commission distributed formal Trade Practice Rules for the Environmental Testing Equipment Manufacturing Industry, effective June 25, 1957. For copies of these rules, write Robert M. Parrish, Secretary, FTC, Washington, D.C.

DIRECTORY OF NEW IEE MEMBERSHIPS

A list of those who have joined since the last issue of the Environmental Quarterly. Where home addresses are shown, company affiliations appear in parentheses.

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IEE HOLD FIRST ANNUAL TECHNICAL MEETING

(Continued from Page 7)

"High Temperature Vibration Measurements," W. R. Elliot, Boeing Aircraft Corporation

Means of calibrating vibration transducers up to 1,000°F. are presented. Two test facilities, one which has an upper limit of 600°F. and another that is capable of vibration testing up to 1,000°F. are described.

"Predicting & Evaluating Low Frequency Vibration Environments of Aircraft," E. J. Kirchman, Glenn L. Martin Company

The problems associated with low-frequency vibration, a condition characteristic of aircraft structure, are discussed. A typical environment spectrum developed and the effects on equipment design, isolator requirements, and environmental testing techniques are evaluated.

"What To Do When It's Too Big To Test," R. M. Mains, Knolls Atomic Power Laboratory

As an alternative to bigger and even bigger test equipment, various constructive steps that can be taken short of complete simulation are discussed. An example is offered in terms of the reactor compartment of a nuclear powered submarine. The need for better definition of damage criteria is emphasized, so that tests and calculations have more meaning.

"Problems of Humidity Instrumentation," J. Boyle, Boyle Engineering Laboratories

Relative humidity, and precision in measuring humidity and other parameters.

"Design Consideration For Advance Performance Temperature, Humidity and Altitude Parameters in a Test Facility," Bernard Friedman, Tenney Engineering, Inc.

This paper covers a forced-air system that provides less than 10° gradient at 350°F. and at 80,000 feet.

"Methods for Estimating Acoustic Environment for the B-58 Weapons System," E. H. Stepp, Convair

Example of the predicted acoustic environment of the airframe structure and electronic subsystem.

"Some Results of Structural Tests Under High Intensity Noise," H. H. Hubbard, National Advisory Committee for Aeronautics

Description of characteristics of the intense noise field encountered near aircraft power plants. Recounting of experience in testing to destruction of simple panels with both discrete and random type noise loading. These tests revealed some of the effects of panel thickness, curvature, and edge conditions, as well as internal pressure.

"Problems In Acoustically Induced Equipment Failure," Dr. I. Dyer, Bolt, Beranek and Newman, Inc.

An outline of the basic problems assumed to be involved in the failure of electronic equipments under high intensity sound.

"Effects of a Heterogeneous Group of Fungi on Military Equipment and Material," Dr. E. J. Keegan, St. John University and Burgoyne Testing Labs.

A short history; physiology and nutritive requirements; effects of sub-zero temperatures; and various microbial defects in relation to Fungus Testing.

"A Critical Analysis of the Salt Spray Test," Carl Durbin, Chrysler Engineering Division

The authors review the history of salt-spray testing, discuss standard test procedures, and present the effects of results. They reveal data to show how salt-spray test results can be used and how they should not be used.

"A Coordinated Approach to Control of the Radio Frequency Environment," W. W. Hill, Westinghouse Air Arm Div.

Definition, effects, and description of RF environment. Design approach to interference control.

"Audio and Radio Frequency Environmental Requirements of MIL-I-6181B," John F. Harrison, Sprague Electric Company.

These requirements are explained in some detail followed by general specific guide-lines for testing to meet the requirements.

END

IEE LOCAL CHAPTER NEWS

NEW YORK METROPOLITAN CHAPTER IS FIRST TO BE CHARTERED BY IEE

NEW YORK CITY—At an Environmental Science Workshop on June 6, Dr. George D. Wilkinson, General Manager, IEE, and Mr. Henry F. Sander, President, IEE, officially welcomed the New York Metropolitan Chapter as the first fully accredited chapter in the Institute of Environmental Engineers.

The occasion was the New York group's summer workshop in which a panel of experts discussed questions presented by the audience of 85 engineers and scientists. Some of the questions had been submitted in writing prior to the meeting.

The panel consisted of Mr. John J. Ragazzi, Assistant Head, Environmental Sect, Arma Div, Am. Bosch Arma Corp.; Mr. John Thompson, Chief, Test Facilities Lab, Rome Air Development Center; Mr. Arthur Billet, Staff Engineer, Aero Hydraulics Div., Vickers, Inc.; Mr. Robert L. Stallard, Staff Engineer, The Glenn L. Martin Co. of Denver; and Mr. Emil Bruno, Supervisor, Environmental Lab, Sperry Gyroscope. The panel moderator for the evening was Mr. Robert Brown, Vice President, Tenney Engineering, Inc.

Although the panel was prepared to discuss any number of environmental testing problems, the bulk of the interest centered around vibration testing. Primary topic became the type of suspension

(Continued on Page 15)

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TESTING IN THE ENVIRONMENT OF TIME

(Continued from Page 5)

conditions of increased severity now has a new definition. This need not deter us, but it will have to be correlated through comparison with data collected under normal conditions to arrive at a coefficient of severity. Meanwhile, we gain time.

Examples of ways of increasing the severity of a test are not difficult to provide. The whole field of environmental testing offers a wide variety of methods to choose from. The test must be enhanced in a way which increases the force of mortality tending to cause failure. Our television sets, to take a case, can be run in enclosures which raise the temperature to some safe but severe level. We might increase the voltage of the power lines from 115 to 130 volts. We might increase the frequency of rotation of the channel selector switch and other mechanisms. We might have the receiver turned off and on more rapidly, and subject it to vibration in various planes. Other electronic equipment, intended for military purposes, might be subjected to thermal shock, using hot-cold chambers. In fact, military specifications require such treatment for testing for other purposes than collection of life-test data. The environmental test engineer will have no trouble in devising ways to increase the severity of a test.

A final word on probability. If we know the probability of survival of a single equipment, it is simple to calculate the probability of survival of n equipments. It equals the single equipment probability raised to the nth power. Tables of logarithms or slide rules give these numbers quickly. Through a rather recent method of sequential analysis of data we can plot the data while the test is running, and see whether the mean time-between-failures is tending toward one of two selected values that interest us.[1]

Summary

We have shown that the question of how long an equipment will survive, under various stated conditions, can be answered through testing in what we like to think is the ultimate environment: *time*. Life-tests provide data from which we calculate an average time-between-failures. With this number we obtain the probability of survival for given periods of time quite easily. Testing time can be shortened through increasing the severity of tests. Data collection can be hastened by running numerous tests simultaneously. We suggest that more serious consideration be given to the value of life-tests, possibly under environmental conditions, as a means of reaching earlier conclusions in the evaluation of performance, or reliability, of new designs in a wide variety of manufactured products.

References:

1. For an explanation of the basic mathematics of life-testing and sequential methods of statistical analysis, see *Annals of Mathematical Statistics*, Vol. 25, 1954, pp. 373-381, or *Wayne University Technical Reports* 1 through 4, 1952, by Benjamin Epstein.
2. More detailed tables are available in various texts. For example, Molina, E. C., *Poisson's Exponential Binomial Limit*, D. Van Nostrand Company, Inc., New York, 1942 (six place tables).
3. For the concept of tests of increased severity, see Simon, Leslie E., *An Engineer's Manual of Statistical Methods*, John Wiley and Sons, Inc., New York, 1941.

END

IEE LOCAL CHAPTER NEWS

(Continued from Page 13)

system to be used in conjunction with a push-rod between the specimen and the shaker. Present objection to the use of push-rods is that suspension systems now in use allow the specimen to experience motion other than in the desired direction. According to the panel, the solution appears to be the design of a suspension system that is flexible in the direction of desired motion and relatively rigid in all other directions. Probably such a system will utilize rubber. Other aspects of vibration testing touched upon were the problems involved in mounting accelerometers directly on specimens, and the relative merits of various test fixture designs. Welded fixtures were said to be satisfactory, but cast fixtures, although most expensive, were labelled best.

Also discussed was the problem of testing materials and equipment under rapidly changing conditions of temperature and altitude.

Officers of the New York Metropolitan Chapter are:

Chairman—Mr. J. C. Ward, Head, Environmental Test Sect., General Precision Labs., Inc.

Vice Chairman—Mr. John Cammarata, Head, Environmental Sect., Arma Div, American Bosch Arma Corp.

Secretary-Treasurer—Mr. Ralph Ferry, Laboratory Supervisor, Allied Control Corp.

Director—(to represent the Local Chapter on the national Executive Committee) Mr. Bernard Friedman, Chief Engineer, Tenney Engineering, Inc.

Board of Directors of the Local Chapter—Mr. G. Chernowitz, Engineering Dept., American Power Jet Co.; Mr. Friedman; Mr. William Camp, Project Engineer, Heinemann Electric Co.; Mr. Lawson Exley, Test Engineer, Aeroflex Research Co.; Mr. Frank Hallstein, Project Engineer, Dayton T. Brown, Inc.; Mr. Norman Meyers, Project Engineer, Stratos Div., Fairchild Engine and Airplane Corp.; Mr. Albert Tramposch, Chief Test Engineer, Parameters, Inc.; and Mr. Roger J. Amorosi, President, Parameters, Inc., and Vice President, national IEE.

PHILADELPHIA—On June 12, the proposed Mid-Atlantic Chapter sponsored a program on "Fundamental Concepts of Random and Sinusoidal Vibration Testing." The two speakers were Mr. Dorman Priest, Physicist, and Mr. Kenneth Metzgar, Electrical Engineer, both of The Calidyne Company, Winchester, Mass. The heavily-attended dinner meeting was arranged by Mr. Henry L. Stein, American Electronic Laboratories, Inc., and Mr. David Askin, Frankford Arsenal.

According to Mr. Askin, this initial meeting drew an enthusiastic audience of 72 persons.

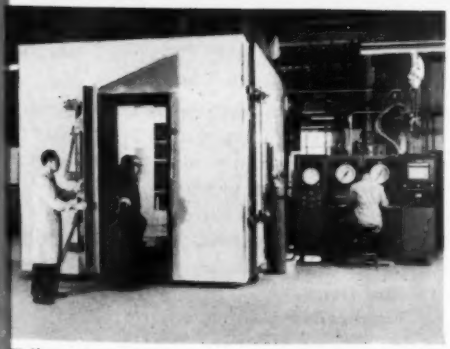
The Steering Committee for the proposed chapter met in the afternoon of the same day and approved a draft of proposed by-laws for circulation to prospective members of the proposed chapter prior to the move for final organization of the chapter. The Steering Committee is made up of: Mr. Askin; Mr. Stein; Mr. Theodore Foti; The Glenn L. Martin Co.; Mr. Stu Hibben, Westinghouse Air Arm Div.; and Mr. Fred Reitz, Emerson Research Lab.

CHICAGO—On Wednesday, June 1957, Mr. James Pauly presented a paper on "Sand and Dust Testing" before a well-attended dinner meeting of the proposed Greater Chicago Area Chapter. Mr. Pauly spoke on the sand and dust environment, how it is created, and its effect on equipment.

Mr. Pauly is a project Engineer at the Southwest Research Institute, San Antonio, Texas. He recently authored a lengthy report on "The Dust Environment and Its Effect on Dust Penetration" for the Wright Air Development Center.

Mr. Henry F. Sander, President of the IEE, who is working with the Steering Committee for the Greater Chicago Area Chapter, reports that the group has made much progress and expects to submit its proposed bylaws and list of officers to the national Executive Committee in the near future. Mr. Sander attributes the success of the June 19th meeting to the effective work of Mr. Stephen S. Danko of Motorola, Inc., who handled all arrangements and mailings with the cooperation of Motorola.

RELIABILITY IN TESTING - COMPARATIVE EVALUATIONS



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Test Space Size: *8 feet high x 8 feet wide x 12 feet deep.*
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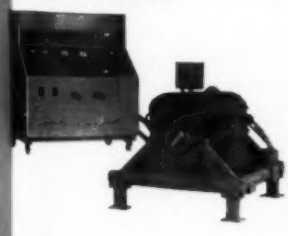

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HOW ENVIRONMENTAL TEST CONDITIONS INFLUENCE RELIABILITY

(Continued from Page 9)

The selection of environmental test conditions is in a sense more critical during the development than the production phase. If they are too severe, they may actually delay the attainment of reliability by directing effort to design problems of minor importance. Yet, since only a few items of each kind will be tested, some "factor of safety" is necessary, or the test cannot verify environmental reliability.

The phrase "factor of safety" is not always easily defined for an environmental problem. One simplified representation of environmental relations in a component assumes a unidimensional stress or environment, and a unidimensional failure, that is, a single type of failure. The service stress is shown by a probability density for many missions, which perhaps is Gaussian. The stress at which failures occurs is shown by a second probability density for many components, which again perhaps is Gaussian. The "factor of safety" may be taken to be the ratio of mean failure stress to mean service stress, and it is clear that the two means must be separated by several standard deviations of both distributions or the component will not be reliable.

This is an excellent concept for reference purposes, and contradicts two assumptions frequently made, that the service environment is always the same, and that t fragility of the component does not vary. For example has on occasion been assumed that because a missile made one successful flight, it is not subject to a vibrati problem.

However, the picture encounters practical difficulties quantitative application. We cannot usually estimate t distributions in detail. We cannot always even selec definite environmental mean from which useful standa deviations can be measured. Both the environment and effect are frequently multidimensional; for example, vib tion must be described by both amplitude (or pow spectral density) and frequency. This complicates the s tistical picture. Furthermore, some environmental te are intended to be accelerated tests, but succeed in t only in part. For example, the common salt spray test usually in fact an accelerated test for the exterior o component, but many produce a mild effective envir ment for the interior by comparison with some anticipat prolonged service conditions.

Frequently, a more feasible and useful approach is determine service environments that are exceeded onl negligible portion of the time and choose test conditi beyond these environmental limits by several standa deviations of the strength of the component. This is even more excellent concept and should be applied quan

tatively when possible, but this will again be limited by the complexity of the practical situation and by inadequacy of data.

It thus appears that in the all-important matter of selecting environmental test conditions, much engineering judgment is necessary, with the aid of such statistical data as may be pertinent and to the extent that its use is feasible.

Shock and Vibration

Shock and vibration are special cases, for they involve many subtleties, and the methods used in analyzing and simulating them have frequently left much to be desired.

Before making any detailed analysis of vibration, it is important to determine what, if any, *sustained* sinusoids are present, and in what ranges the vibration is random. Random vibration should be analyzed in terms of power spectra and simulated primarily by a noise shake. The analysis can be performed on an ordinary wave analyzer with only slight modifications. Fortunately, apparatus for noise and complex wave shaking is becoming commercially available.

Shocks should be analyzed in terms of shock spectra and simulated by pulses that are specified primarily by their shock spectra. No simple description of pulse shape as such gives a quantitative measure of the damage a typical service shock may do to a component. Conversely, when a test shock is specified entirely in terms of pulse shape, it is ordinarily impossible to place tolerances on the pulse shape so as to control its damaging characteristics. We must remember that in applying shock and vibration to components we are primarily testing their interior rather than their mounting points. We must not be content with analyses or simulations resulting in stresses that are adequate and reasonable merely at the mounting points.

Combined Environments

There is no question that we want to test to combined environments, and, up to a point, we cannot escape it. Any environmental test carries with it a temperature, either prescribed or implied. We naturally want to vary the auxiliary environments in the test so as to disclose any important interactions. However, judgment must be used here. For example, there would be little profit in investigating the susceptibility of a component to fungus at −60F. Furthermore, careful inspection after salt spray may yield more information than a subsequent vibration test. On the other hand, a storage test makes more sense if a simple temperature program is prescribed along with the storage time.

Complex wave testing may be considered a special case of combined environment, namely, the combination of several frequency bands simultaneously so that any interaction effects in the component can be observed. In special cases, this can be quite important. For example, a relay may respond in the region of one frequency only when

(Continued on Page 22)

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HUMAN OCCUPANCY IN THE ENVIRONMENTAL CHAMBER

STUART GILES, BEMCO, Inc.

"The 'sports' who run into the –65° F chamber in str clothes to make that quick adjustment of the test equipm should be locked out. A few good whiffs of sub-zero can frost-bite the lung tissue . . . The best saf device is common sens

Providing all the safety devices that may be needed in an environmental chamber is often difficult or impractical. Thus it is necessary to work out minimum requirements for the safety of those who must work in an extreme environment or are to be tested themselves for resistance to various environments. The relationships among the factors of number, activity, age, and physical condition of those who must work together in a given environmental chamber are all variables that are difficult to determine and evaluate. My purpose here is to point out some of the hazards that the operating engineer should be aware of while supervising personnel within an environmental chamber.

Dearth of Information

There is an abundance of reference works offering design criteria for providing comfort for human beings by means of heating and air conditioning. But there is to be found little information on the minimum standards for maintaining personnel safety under conditions of extreme temperature, humidity, altitude, and similar environments. Air handling, whether in the provision of fresh air or the purification of used air, reflects in equipment, energy, and material costs.

The recently intensified Arctic engineering program carried on by the Department of Defense and particularly the present expedition in the South Pole area is generating much valuable information on men operating at very low temperatures. The Army Engineers and others have done a considerable amount of work in the study of personnel operating in desert climates, under hot, dry conditions. Altitude research is going on in many government agencies and private research establishments.

Vital Combustion

The first consideration in environmental occupancy is the requirement for fresh air. The first problem is to insure enough oxygen for the maintenance of life. The rate combustion in the human body and this amount of oxy required depends on the physical activity of the in vidual. This varies from a basal energy expenditure rate some maximum, depending on the individual's ability exert himself. Fortunately, this maximum rate cannot kept up for any appreciable length of time and is of lit importance to the design engineer. Figure 1 illustrates t general range of oxygen consumption for a human bei under various rates of energy expenditure.

The body consumes approximately five volumes of ox gen for every four volumes of carbon dioxide produce Air normally contains about 21% oxygen and 79% nit gen by volume. Since only part of the inspired oxygen used, more air must be breathed than is necessary for t support of life. This is why in the illustration, the cfm fresh air supplied is different from the cfm of oxyg consumed.

The amount of air that is breathed is regulated by t chemical influences of carbon dioxide and oxygen on t nervous system. The body attempts to maintain the carb dioxide concentration in the lungs between five to fi and one-half percent. When the carbon dioxide concentr tion rises slightly above this control value, breathing stimulated. More air rushes in and out of the lungs so th the carbon dioxide concentration is then reduced by dil tion. In contrast to the sensitivity of the body to t changes in the carbon dioxide concentration, the nervo system responds slowly to changes in oxygen concentr tion. If the air contains less than 13% oxygen, breathi is quickened and unconsciousness may result as the bo attempts to reduce its oxygen requirements. This is t condition that we find at high altitudes. Above 13%, th oxygen concentartion regulates the breathing indirec by the carbon dioxide concentration. The control is sim lar to that of a simple thermostat. Changes in carb dioxide concentration act as temperature changes a actuate the sensing element. Changes in oxygen conce tration act as changes in the temperature setting of thermostat.

Keep in mind the fact that one man in a room of s seven by ten feet, seven feet high, will have enough oxyg supply for hours of occupancy. I do not intend to give th impression that the fresh air requirements illustrat

MR. GILES is a mechanical engineer on the staff of BEMCO, a manufacturing member of the EEI, and is a graduate of Stevens Institute of Technology. Mr. Giles is also a Commander in the Naval Reserve and a member of the A.S.H. & A.E. and the S.E.E.

must be maintained on a continuous basis. If a number of people are crowded into a small chamber, the oxygen supply will be used up and the CO_2 concentration will rise very rapidly. A common standard is that minimum rate of fresh air in a very crowded space, say with 30 to 50 cubic feet per person, should be at ten times the volume of fresh air each man normally breathes. This is, of course, a "rule of thumb" used in situations such as ships' compartments where personnel are confined for many hours at a time. It will rarely be necessary to provide this quantity of air in the average environmental chamber. If many persons must be crowded into a small chamber, and only enough oxygen is supplied to prevent excessive carbon dioxide concentration, another problem will arise. The occupants will probably be nauseated by odor before they feel any oxygen or CO_2 affects. Dilution by large quantities of fresh air (in the neighborhood of 10 to 20 cfm per person) is necessary under these situations or filtration with air purification equipment may be used to reestablish reasonably comfortable odor conditions.

Suffocation and Poisoning

Suffocation is due to lack of oxygen and can take place in a sealed chamber from the introduction of any gas which displaces the air. The inhalation of poisons is another matter. A reaction takes place within the body. Carbon monoxide is a poison in that it enters the blood stream and absorbs oxygen out of the body's system, thus producing an oxygen deficiency. Other oxydizing agents have a similar effect. Certain commonly used chemicals such as carbon tetrachloride can produce poisoning to one degree or another. Poisoning of course does not necessarily mean death but may simply produce temporary illness or irritation of the mucous membrane.

There are various ways to protect personnel by observation. Heart beat and pulse rate are probably the most easily measured. This can be done by the occupants themselves or by small microphones strapped around the chest and used for monitoring the heart from a remote location. Instrumentation is available for monitoring the CO_2 and O_2 concentration in the air by means of liquid absorbents or thermoconductivity of the gas in the space. An instrument called the Pneumograph is available for not only measuring the rate of respiration but the depth of respiration as well. Observation of a man's movements and speech are also excellent indications of his physical condition. One or more of these safety devices should always be used when personnel are working in environmental chambers. The assumption that safe conditions exist must never be made. It is also recommended that any chamber in which personnel will work for more than half an hour at a time be equipped with a fresh air supply of 3 cubic feet per minute per person. Chapter 8 of the *Heating, Ventilating, and Air Conditioning Guide for 1957* contains extensive data on air contaminants of many types.

(Continued on Page 25)

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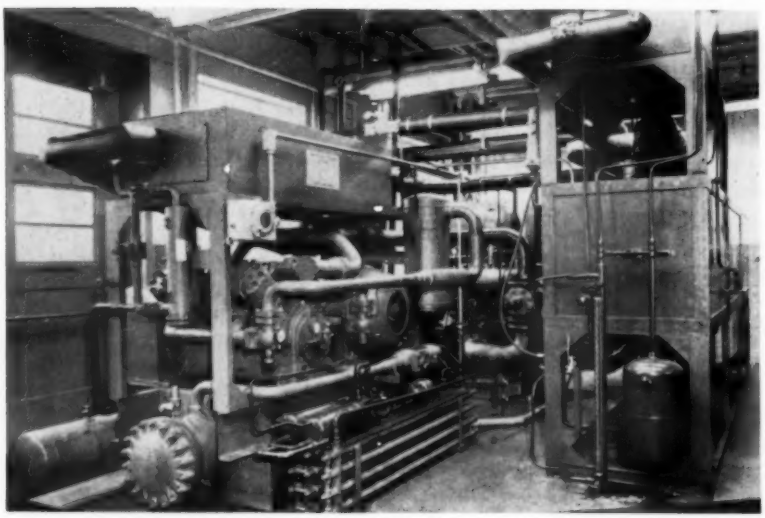

American Research Liquid Chilling Unit

The American Research Corporation has developed the premise of specialization rather than mass production in the manufacture of environmental test equipment.

Realizing that a need for individually designed equipment, the American Research Corporation has augmented its standard line with custom designed units for specific applications.

This comparatively young concern has combined its considerable experience in the field of custom-built equipment to originate the present business early in 1953. Under the direction of its president, Jack Shamroth, who originally entered the field in 1942 in design and manufacturing, the company has continued to expand and has recently moved into a new building occupying 9,000 square feet in Farmington, Conn.

Contributing to its growth are two of the company's principals, Vice President Ted Augustyn, in charge of engineering and manufacturing, and Application Engineer Tom Hinchliff, each with more than ten years experience in the industry.

One of the company's first specialized units was a sand and dust chamber featuring automatic dust density control, which permits tests to be set up for long runs without constant manual regulation. Engineering for the unit was based on an entirely new concept of streamlined air flow, which made it possible to lower the power necessary to move the air and to reduce the floor space required, while at the same time minimizing air side-pressure drop.

Two unusual installations for a jet-engine component and control manufacturer consisted of a liquid chilling unit (shown in the photograph) capable of lowering or raising the temperature of jet fuel to simulate actual operating temperatures. This conditioned fuel is supplied to jet fuel controls and components operating in a chamb at specific temperatures, altitudes, and relative humidities. The se ond unit it a low-temperature, high-altitude air chiller which lowe the temperature of air supplied for various types of electronic equi ment and components, and simulates actual operating temperatur and altitudes.

A new design in the simulation of high altitude condition has bee developed by American Research Corporation in a chamber th utilizes radiant heating and cooling from the five walls and the do in addition to the normal method of heating the air. By this mea radiant heating and cooling is provided at all altitudes up to 250,0 feet, well beyond the normal good testing range of heated air at low altitudes. The operating range of this chamber is from low temper tures of $-100°$ to $+500°$ F.

The most recent development is a new temperature-altitude-humi ity walk-in test chamber that provides unusual flexibility for sim lated flight testing of electronic components. The free work space 7 by 10 by 8 feet high may be partitioned with specially designe removable panels to make three separate test compartments all wi separate temperature controls simultaneously. Completely self-co tained, the chamber requires only power and water to put it in operation.

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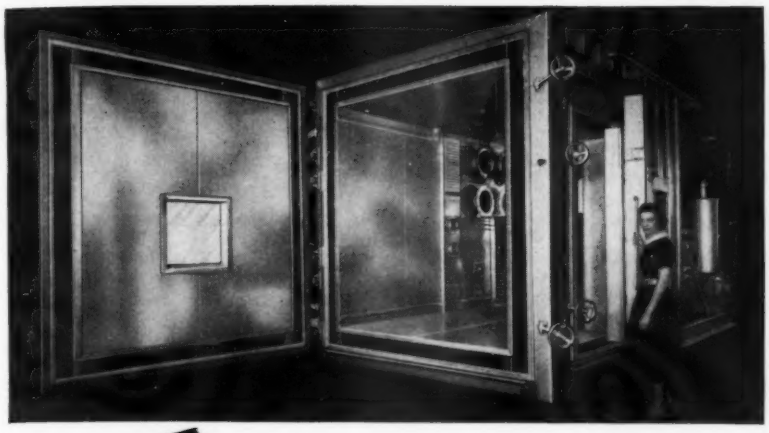

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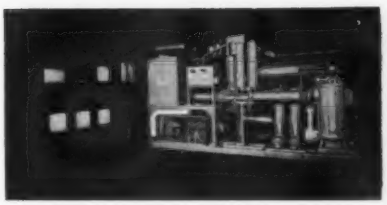

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Review of Environmental Test Equipment, John Cammarata, *Electrical Mfg Magazine*, May 1957. Reprints available from the magazine.

Dateline World—A new feature in *Aeronautical Engineering Review*. Engineering and scientific news notes from all over the world.

1—Fungi organisms available to industry. Twenty-four hour delivery service. Burgoyne Testing Labs, Westbury, Long Island, N. Y. This and complete environmental metallurgical, chemical, and quality control testing facilities covered in new 24-page brochure.

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3—Bulletin No. 4 reports ceramic-insulated wire to be particularly applicable for high radiation fields, high pressure, and high and low temperature – 400° F to 2,000° F. Aero Research Instrument Co., Chicago.

4—Measuring fluid flow under difficult conditions and at high temperatures and pressures is discussed in Bulletin S-1 by Potter Aeronautical Corp., Union N. J. Design uses hydraulic pressure of the measured fluid to suspend the turbine-type rotor in a floating position.

5—Research and testing center described in new bulletin. Abrams, Instrument Corp., Lansing, Mich. Tests: Altitude, temperature, humidity, vibration, acceleration.

6—A new rack/panel pressurized connector for high-altitude and vibration applications is featured in firm's DPS Series. Bulletin DP-101. Cannon Electric Co., Los Angeles.

"The ARDC Model Atmosphere, 1956" by R. A. Minzer and W. S. Ripley of Geophysics Research Directorate, Air Force Cambridge Research Center. This is No. 86 of Air Force Surveys in Geophysics series. AFCRC TN 56-204; ASTIA Document 110233. Availability: *Free* to companies holding and referencing Government contract from Armed Svcs. Tech. Info. Agency, Doc. Svce. Center, Dayton, O. *Others* should write Off. of Tech. Info. Svce., U.S. Dept. of Commerce, Washington 25, D.C. Price unknown.

HOW ENVIRONMENTAL TEST CONDITIONS INFLUENCE RELIABILITY

(Continued from Page 7)

disturbed from balance by resonating in the region of another.

Vibration excitation along more than one axis simultaneously is another special case of combined environment. This is ordinarily not feasible at present. It is desirable, since interactions may occur, but not quite so important as is frequently judged, for the responses of the component are at its directions of resonance rather than along the direction of excitation. A resonance that is not aligned with one of the three orthogonal axes that successively constitute the axes of excitation responds for more than one orientation, and the decrease of maximum response by misalignment is not a large effect.

Two important cases are temperature in conjunction with shock and vibration, and sustained acceleration in conjunction with vibration. The first test is not unfeasible and is of some importance because temperature can influence the fragility of materials. The second is more difficult and represents a major gap that may not be closed in our environmental programs for some time to come, that is, until it becomes feasible to operate a vibration table subject to sustained acceleration. It does not follow, however, that such combined tests must be pursued as intensively as vibration at room temperature or acceleration and vibration separately. The facilities for such tests are necessarily elaborate, and the failures in such tests tend of second order importance.

In short, such tests are refinements. Their advisability is dependent in part on how realistically the individual environments have been simulated. If random vibration is simulated by sinusoidal or vice versa, especially if the utmost care is not taken, there is little further to be gained by combining it with sustained acceleration. The lack of a combined vibration-acceleration test may be made up for crudely by a slight increase in the factor of safety for both environments, or by extending the frequency range of complex wave testing down to extreme low frequencies. It must be remembered that "sustained" acceleration differs from vibration only in that its spectral content is so low in frequency that it can excite no resonances in the component.

Conclusion

We have thus seen that environmental test aids in the attainment of reliability although the extent of this aid is difficult to measure accurately, that a statistical concept must be used as a background for engineering judgment in specifying environmental requirements, although it is difficult to apply quantitatively in practical situations, and that tests to combined environments are desirable but should be specified with judgment and restraint, particularly until our tests to individual environments are better perfected.

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(Continued on Page 24)

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Dr. George D. Wilkinson, General Manager of the IEE and the EEI, has issued a request for basic data on services offered by all laboratories who perform environmental testing on a commercial basis. According to Dr. Wilkinson, his office will compile and publish a directory of such laboratories.

Environmental test labs are urged to forward specific data on the test services offered just as soon as possible. Bulletins and brochures should be included, but a carefully worked out condensed listing of services would be most helpful. Send information to *Environmental Lab Directory Editor,* 9 Spring St., Princeton, N. J.

NEW PRODUCTS

(Continued from Page 23)

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6—Two new environmental test units by International Radiant Corp., Port Washington, L. I., N. Y. Walk-in chamber: 10′ x 10′ x 8′ high. From −100° to +400° F or wider. Altitude to 100,000′ or higher. RH 20 to 95% with dew point limit of +35° F. Rain rate of 4″ p hour. Also explosion-proof six-tank bath unit, each tank ha 9″ x 5″ x 12″ deep interior free working space.

7—Transistor clip of tempered berylium copper designed to re all popularly used transistors under conditions of severe accelera deceleration, shock and vibration. The Birtcher Corporation, Angeles.

8—High-speed platinum resistance thermometers for tem ature sensing in noncorrosive liquids and gases, Trans-Sonics, In Burlington, Mass. Thermal responses of under 2.5 seconds in air less than 50 milliseconds in water. Temperature range from −32 to +750° F; accuracy better than ±1% of full scale and repeatab 0.2%.

9—Sensitive general-purpose recorder measures and record millivoltage signals as low as one millivolt full-scale. For use v various transducers in scientific research, laboratory experimenta etc. General Electric Co.

10—Electric deflection gage for straightforward reading of st tural deflections during static testing of airplanes or structural pa Waldale Research Co., El Monte, Calif. Company claims this gage be read out on existing strain gage equipment, indicates greate curacy than previous methods, is designed for ranges from 0 through 0—150″ deflections, and is easily installed and used.

11—A digital mass flowmeter, the DIGIMAF, is designed to s the difficult problem of measuring true mass flow rate of liqu vapors, gases, or multiphase combinations over temperature ra from those of cyrogenic fluids (−423° F) to high temperature g (+1000° F). Inertial Instruments, Inc., Santa Monica, Calif.

12—New line of low-cost vibration isolators for airborne eq ment, the "Lo" Mount, designed for compliance with MIL-C-1 Transmissibility at resonance below 2 in all load ranges. Low na frequency. Unique spring and friction-damping design. Barry C trols Incorporated, Watertown, Mass.

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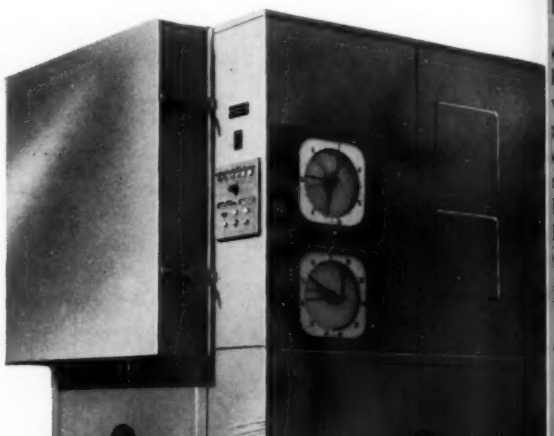

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Well, here it is — that impossible-to-do high and low temperature chamber —100°F to + 1000°F ALL IN ONE CHAMBER.

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HUMAN OCCUPANCY IN THE ENVIRONMENTAL CHAMBER

(Continued from Page 19)

Temperature and Humidity Problems

Unusual temperature and humidity conditions in the environment trigger a complicated system of checks and balances within the human body which attempt to counterbalance any change in its normal rate of heat loss. When men are working in low temperature chambers they must always be equipped with special cold weather clothing. This clothing is in a fairly high state of development and runs from the usual wool insulation type of clothing to the more complex electrically heated suits.

The problem of breathing and the face mask has never been entirely solved. Visibility and ease of breathing are often restricted by the equipment that must be worn. For this reason there are probably more accidental cases of frost bite of the face and lungs than any other type of environmental testing accident. We humans cause them by impatience with protective gear and neglect of simple precautionary measures.

Strict discipline must be maintained when working in temperatures below freezing. The "sports" who run into the −65° F chamber in street clothes to make that quick adjustment of the test equipment should be locked out. A few good whiffs of sub-zero air can frost bite the lung tissue. Internal damage of this type does not heal readily and the damage is permanent. Frost bite of the nose and ears may necessitate amputation which is equally permanent.

Another hazard not commonly understood is the *wind chill* factor. High-velocity air movement increases the heat loss of the skin many fold and frost bite may occur very quickly even at temperatures of −20° F. Most environmental chambers have air circulation fans of one sort or another that produce high air velocities within the space. These fans should be turned off when human beings are working within the chamber. It they must be kept running for temperature control, extreme caution should be used.

High Temperature Work

Work in elevated temperature conditions of 100° F and over requires care just as in low temperature environmental work. Under these conditions the body again tries to balance its heat loss mechanism by increasing the rate of perspiration and reducing the metabolic rate. If the condition is extreme, or even under mild conditions for extended periods of time, heat prostration is the result. The increased perspiration rate, of course, produces dehydration and an exccessive loss of salt. Salt tablets should be taken along with water if it is necessary to work in these environments, and the heart should be observed carefully as well as skin temperature and respiration rate. The effects of this type of exposure may be delayed and a man may not feel the effects for a few hours after he stops working in the elevated temperature environment.

Protective clothing problems at high temperatures for long periods are more difficult to solve than for low temperature. What is required is a ventilated suit cooled by an external source of air. Short exposure protection can be obtained with ordinary insulating type clothing or fire fighting outfits. Breathing high temperature air is hazardous and good face masks must be worn.

Explosion and Fire Hazards

Automatic fire extinguishing devices are good insurance Unfortunately they will incapacitate personnel and therefore should be deactivated when the chamber is occupied. Test personnel within a chamber should not attempt to fight a fire, no matter how small, when the chamber door

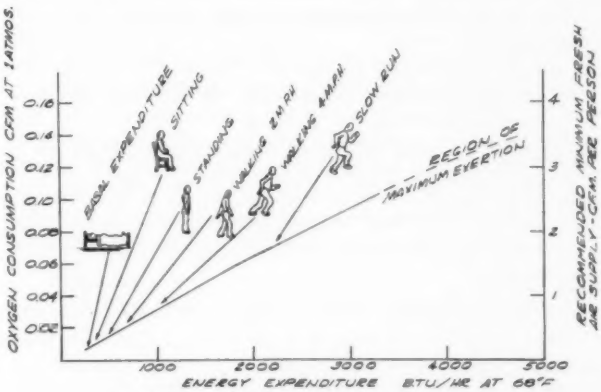

Figure 1. General range of oxygen consumption.

is closed. The oxygen supply will be rapidly reduced below the survival level.

Radiological Problems

The Atomic Energy Commission and others have in recent years done much work on radiological safety. This environmental hazard is new and much is to be learned. Various medical research laboratories are working on it continuously. In such a specialized field, specialized help must be obtained to supervise the operations. Simple instrumentation, such as Geiger Counters are available which will give a warning of hazards. Dosimeters to be worn on the person are reliable devices for indicating the hazard to which an individual has been exposed.

Considerations in the Design of an Environmental Chamber

Large, carefully-placed observation windows for supervising work within a chamber are probably the most valuable safety device of all. Escape doors, shut-off switches and valves, and alarm signals should be also at the top of the list. Many automatic gas analyzers are available which will warn of danger. It is usually impractical to equip a chamber with analyzers for every conceivable gas hazard, and thus the types of tests to be conducted govern the selection of this equipment.

It has not been my intention to frighten test personnel who must work in various environmental extremes. Successful tests are being performed under the most extreme conditions at many laboratories without accident or hardship. The best safety device yet devised is common sense. Unfortunately, this is an uncommon commodity, and careful, firm, and continuous supervision by a well-trained, experienced engineer is essential to safety.

END

CONTRIBUTIONS INVITED FOR HANDBOOK OF THE ENVIRONMENT

The Committee for the *Handbook of the Environment* has begun preparation of prototype chapters to be used as models in the formulation of other portions of the projected *Handbook*. The Committee has held two national meetings, one in Chicago at the time of the Annual Meeting of the IEE in April and the second at Wright Air Development Center on June 18.

The outline is now reasonably firm and every effort is being made to enlist the voluntary services of authorities in the various fields of environmental testing for the preparation of specific chapters or sections. To this end, individuals interested in making contributions to the *Handbook* are urged to write directly to Mr. Ray H. Mattingley, Executive Secretary, Committee for the *Handbook*, 9 Spring St., Princeton, N. J., stating their qualifications and making specific proposals regarding what they would like to contribute. Outlines will be furnished to contributors.

Other members of the Committee are Dr. Alan E. Surosky, Manager of Mfg, Nuclear Development Corporation of America; Mr. Frank Barnes, General Mgr, Hudson Bay Co., Div. of Labline, Inc.; Mr. John Cammarata, Head, Environmental Sect., Arma Div., American Bosch Arma Corp.; Mr. Charles E. Earl, President, Alpha Electric Refrigeration Co.; and Mr. John R. Grimm, Asst Chief, Environmental Criteria Branch, Wright Air D velopment Center.

The *Handbook* is to be published section by section loose-leaf for insertion in a binder cover. The loose-l form is planned not only to facilitate supersession of o solete material but also so that publication can begin soon as the first major sub-division is ready.

The *Handbook* will be offered for sale on a subscripti basis at a price yet to be determined. Members of the I will have an opportunity to buy the *Handbook* at a pri considerably below that offered to non-members.

The *Handbook* will cover: Scope of environmen testing and simulation; state of the art and the indus types of environmental equipment and their gene application; environmental simulation and testing te niques; instrumentation; characteristics of the envir ment; new frontiers; design and operating formulas; a a bibliography.

Those who have already expressed willingness to ma contributions to the Handbook are: Mr. David Ask Frankford Arsenal; Mr. J. T. Thompson, Rome Air D velopment Center; Mr. G. W. Gerhardt, WADC; Mr. P. Zukauskas, The Glenn L. Martin Co., Baltimore; and M Robert L. Stallard, The Glenn L. Martin Co., Denver.

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Winners of the contest will be introduced in the *Environmental Quarterly*.

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For further details, write Institute Headquarters.

Air Force Baloonist Reaches 96,000 Feet

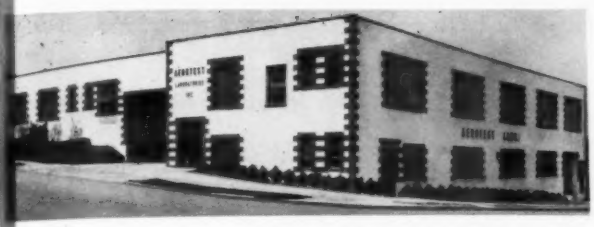
Capt. J. W. Kittinger Jr., U.S. Air Force, riding a seal gondola set a new altitude record for lighter-than-air cr in a flight last month over Minnesota.

The achievement of a height of 96,000 feet in safety h been made possible through the simulation of high al tudes in environmental test chambers on the ground. I this technique scientists and engineers are able to expo human beings, equipment, and sealed containers to t equivalents of higher and higher altitudes under ca fully controlled conditions.

Thus the problems to be encountered high above t earth are gradually met and solved in advance.

At the Wright Air Development Center near Dayto Ohio, six steel environmental test chambers designed f the simulation of zones 50 miles above the earth a higher are in daily use. All in the day's work, "spacem enter these chambers to help find out how man must b have under these formerly unmeasurable conditions.

The Air-Force is also conducting high-altitude bail-o tests, using partial pressure suits and pressure helme Gondolas for balloon transport to high altitudes are fi tested unmanned and then manned in the altitude simul tion chambers.



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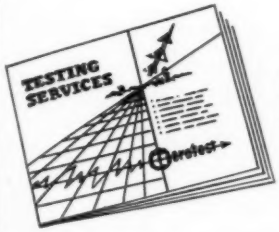

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WORLD'S LARGEST SOLAR FURNACE TO BE USED FOR TEMPERATURE TESTING OF METALS

Air Research and Development Command physicists at Holloman Air Development Center and are designing a gigantic solar furnace to be constructed near Cloudcroft in the Sacremento Mountains of south-central New Mexico by 1959.

One of the most important applications of the furnace will be the studying of the effects of rapid temperature changes on metals used in missile structures.

The new furnace is expected to produce temperatures as high as 8,000 degrees Fahrenheit, which is about 70 percent of the temperature at the surface of the sun. Users of the furnace will be the Air Force, Army, Navy, Atomic Energy Commission, National Advisory Committee for Aeronautics, and various industries engaged in national defense work.

Dr. Knox Millsaps, chief scientist at HADC, will head a special group this summer to investigate the problems of solar furnace construction and applications.

Developer of the theory of design to be used in the construction of the furnace's heliostat mirror is Dr. Paul Jose, director of HADC's Research and Development Materials Branch.

By means of a 130- by 140-foot heliostat and a giant parabolic mirror, collected solar energy will be increased from 0.028 to 700 units per square centimeter.

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IEE SELECTS NEW YORK CITY FOR 1958 MEETING

The Committee on Arrangements for the 1958 Second Annual Technical Meeting of the IEE, headed by Mr. Roger J. Amorosi, Executive Vice President, and President of Parameters, Inc., has selected New York City and has set tentative dates of April 24 and 25, 1958. Mr. Henry F. Sander, President of the IEE, Chief Test Engineer, Vapor Heating Corp., has invited the New York Metropolitan Local Chapter to act as honorary host for the national meeting and to assist the Committee in every way possible

At the present time, general subject matter for the 1958 meeting, according to Mr. Arthur Billet, Program Chairman, is to be vibration, acoustic noise, climatic conditions, radiation, and explosion. Mr. Billet, Staff Engineer of Vickers, Inc., is a vice president of the IEE.

Other members of the Committee on Arrangements are: Facilities and Finances, Mr. John Cammarata, Head Environmental Test Sect., Arma Div, American Bosch Arma Corp., and Publicity, Mr. Norman Meyers, Project Engineer, Stratos Div, Fairchild Engine and Airplane Corp.

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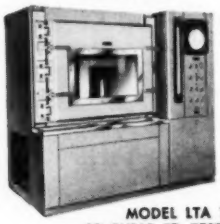

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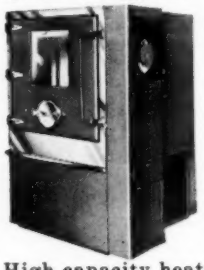

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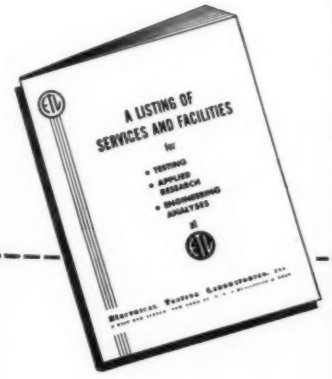

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